Urban Density (Indicator ID: 7000)

Measure
Human population per square kilometre of existing and proposed development areas. Total area is adjusted to exclude parks and other designated greenspace.

Purpose
To assess the human population density in the Great Lakes basin, and to infer the degree of inefficient land use and urban sprawl for communities in the Great Lakes ecosystem.

Ecosystem Objective
Socio-economic viability and sustainable development are generally accepted goals for society.

Endpoint
The most efficient and ecologically sustainable conditions will occur when large urban centres are intensively developed with a high population density. The contrary exists for sparsely populated rural areas — the lower the population density the less stress is imposed on the ecosystem. As a corollary, new growth is best accommodated by adding to the high density area rather than the lower density rural areas.

Features
Urban density is a relative measure of efficiency. In general, and other things being equal, higher density land use is less energy and resource consuming and thus is more efficient from an ecosystem perspective. For example, transportation in higher density areas is less resource demanding since distances are shorter and public transportation is often more available and inexpensive. Consequently, air pollution should be lower in more densely populated areas. In addition, since inefficient land use for urban development implies loss of land use for natural and other purposes there are significant biodiversity dimensions to inefficient land use. In general, the less land used for development, the greater the opportunities that exist for natural biodiversity goals to be met. Urban densities have been declining over time as urban development has become much more sprawling with the vast majority of new development occurring on former agricultural or natural lands. This has resulted in greater reliance for urban residents on the automobile as virtually the only method of public transit for these widespread and low density new communities has become impractical. Information for this indicator needs to be collected perhaps every 5 or 10 years as changes in density take place relatively slowly.

Illustration
This indicator will be displayed by a numerical ratio of population to land area (population per square kilometre).

Limitations
This indicator is useful in comparing municipalities to each other, but would need to be aggregated into an index in order to be represented as a basin wide measure. Identifying park space may be complicated and difficult in some cases because the information most likely exists only at the local level and would require a survey to collect.

Interpretation
The indicator is a simple representation of urban efficiency since higher density communities typically are lower in cost and less intrusive on the rest of the ecosystem. Thus, the higher the ratio of population per square kilometre of land the better in achieving overall urban efficiency and a less stressed ecosystem.

Comments
The indicator is also a good proxy for commercial and industrial sprawl since development patterns for this sector typically parallels that of residential development. The socio-economic paper of SOLEC '94 indicated the relative urban densities between the City of Toronto, Ontario and Chicago, Illinois. The SOLEC '96 Land Use paper also discussed at length the efficiency aspects of higher density through the report.

Unfinished Business

Relevancies
Indicator Type: state
Environmental Compartment(s): land
Related Issue(s):
SOLEC Grouping(s): **land use**
GLWQA Annex(es):
IJC Desired Outcome(s): 9: Physical environmental integrity
GLFC Objective(s):
Beneficial Use Impairment(s):

Last Revised
Feb. 24, 2000

Land Cover – Land Conversion (Indicator ID: 7002)

Measure
Percent change in land use type, including agriculture, urban development, and forest, marsh or other natural cover.

Purpose
To assess the changes in land use within the Great Lakes basin, and to infer the potential impact of land conversion on Great Lakes ecosystem health.

Ecosystem Objective
Sustainable development is a generally accepted land use goal for Canadians and Americans. This indicator supports Annex 13 of the GLWQA.

Endpoint
Zero change would be sustainable but probably unrealistic, while reversion of other uses to the natural ecosystem would be desirable.

Features
High rates of land conversion place stress on the natural ecosystem and are typically associated with inefficient land use, such as urban sprawl. Population growth is a driver for more development which displaces both agricultural and natural lands. Other things being constant, high conversion rates are associated with rapid rates of urban sprawl which is economically inefficient and displaces natural land that serves other biological purposes in the ecosystem or agriculture which in turn may convert land from natural uses. The conventional pattern of land conversion has been for urban growth to displace agricultural lands which, in turn, expand into remaining lands. Urban development also expands into natural lands.

Illustration
The indicator allows easy and visual interpretation of land use changes and trends. Land conversion is an evolutionary process and this indicator will be displayed as a graphical representation of land use by category in the basin.

Limitations
This indicator provides a measurement of the conversion of the land use type, but not of the change in quality of the land use. For example, conversion of a highly intensive, chemical-intensive agriculture area to an urban area, particularly one that is well-planned and utilizes environmental and resource conservation management plans, may result in less stress to the ecosystem. Also, urban development on excavated, landfill or other contaminated sites may also be positive changes.

Interpretation
Generally, land that converts from natural to agricultural and from natural and agricultural uses to developed uses is undesirable. Conversion back to natural uses would be desirable.

Comments
SOLEC '96 represented the rate of land converted from agriculture to developed urban uses. Clearly, loss of agricultural land in the basin places pressure on other lands such as forests and wetlands to be placed into agricultural uses. Satellite imagery might be useful in detailing the changes over time of the urban frontier actually developed and this indicator.

Unfinished Business

Relevancies
Indicator Type: pressure
Environmental Compartment(s): land
Related Issue(s):
SOLEC Grouping(s): **land use**
GLWQA Annex(es): 11: Surveillance and monitoring, 13: Pollution from non-point sources
IJC Desired Outcome(s): 9: Physical environmental integrity
GLFC Objective(s):
Beneficial Use Impairment(s):

Last Revised
Feb. 24, 2000

Brownfield Redevelopment (Indicator ID: 7006)

Measure
Total acreage of redeveloped brownfields.

Purpose
To assess the acreage of redeveloped brownfields, and to evaluate over time the rate at which society rehabilitates and reuse former developed land sites that have been degraded by poor use.

Ecosystem Objective
Sustainable development is a generally accepted goal for North American society.

Endpoint
Elimination of all brownfield sites.

Features
"Brownfields" are abandoned, idled, or under-used industrial and commercial facilities where expansion, redevelopment, or reuse is complicated by real or perceived environmental contamination. Some of the sites contain underground storage tanks; others have contaminated soils from industrial waste or manufacturing byproducts. Still others may possess no contamination at all, but the fear of contamination nonetheless scares prospective buyers and lenders away. This creates an incentive for development to occur in pristine, undeveloped areas.

The indicator would describe trends in brownfields redevelopment and urban renewal, including areas that technically can not be described as brownfields. The indicator is a measure of the rate at which society is employing former contaminated (typically industrial) sites to new and more environmentally compatible uses. Brownfields reuse offers an opportunity to reduce pressure on the ecosystem by slowing the rate of land conversion and typically increasing urban densities. An inventory of contaminated sites is maintained by most provincial and state and federal governments, although a broader definition would require municipal involvement. The goal is to redeploy all of these lands as soon as possible.

Illustration
The total number of identified acres of outstanding brownfield sites throughout the basin by state/province and lake basin. Bar graphs could be used to demonstrate changes over time.

Limitations
The identification of brownfield sites is limited by the availability of information on vacant and redeveloped sites. Data for this indicator may not reveal an accurate trend in brownfield redevelopment, particularly if redevelopment on brownfield sites results in another use that causes further land contamination.

Interpretation
Reducing the number of acres/square kilometres of brownfield sites can be seen as a positive development in the basin. Increasing brownfield inventories not only indicate challenges of dealing with contaminated sites but also opportunities for redevelopment.

Comments
Numerous examples are available including one site in Detroit that has been converted to a public park. Others are typically reduced as urban housing or clean industrial use.

The achievement of the end point will depend on the opportunities available for new land uses as an alternative to land conversion.

Unfinished Business

Relevancies
Indicator Type: human activity
Environmental Compartment(s): land
Related Issue(s): stewardship
SOLEC Grouping(s): **land use**
GLWQA Annex(es):
IJC Desired Outcome(s): 9: Physical environmental integrity
GLFC Objective(s):
Beneficial Use Impairment(s):

Last Revised
Feb. 24, 2000

Ground Surface Hardening (Indicator ID: 7054)

Measure
Percentage of land that is covered by buildings, roads, parking lots and other hardened surfaces.

Purpose
To indicate the degree to which development is affecting natural water drainage and percolation processes and thus causing erosion, and other effects through high water levels during storm events and reducing natural ground water regeneration processes.

Ecosystem Objective
Sustainable Development

Endpoint
Imperviousness mitigated through land management engineering (storm ponding, swells, etc.)

Features
This indicator is realted to land conversion indicator for new development. It is also is expected to be indirectly proportional to the amount of high density development taking place, although low density sprawl that includes shopping malls etc. may be similar to high density imperviousness

Illustration
New urban development without storm retention ponding or other conservation management systems in place.

Limitations
As noted above this indicator may appear be in conflict with other efficiency indicators, such as urban density. However, used as a basin-wide measure it is a valuable indicator of groundwater recharge. It is also not clear that runoff will not receive percolation after being diverted away from impervious surfaces or that it poses significant ecosystem implications in itself - it may be just a measure of development that has more significant effects.

Interpretation
The interpretation is that hardening of surfaces is generally undesirable.

Comments
Data for this indicator should be fairly easy to achieve by estimating the rough proportions of built up areas that are harder from the softer ground cover portions by examination of aerial or satellite photos.

Unfinished Business

Relevancies

Last Revised

Water Withdrawal (Indicator ID: 7056)

Measure
Water use per capita in the Great Lakes basin.

Purpose
To assess the amount of water used in the Great Lakes basin per capita, and to infer the amount of wastewater generated and the demand for resources to pump and treat water.

Ecosystem Objective
Sustainable development is societal goal for the Great Lakes basin.

Endpoint
Resource conservation means reducing the amount of water that is used and the amount of wastewater that results from that water use. Current North American water use rates are in excess of 300 litres per day - reducing that by 50% is desirable and consistent with some European countries.

Features
The indicator provides a quantitative measure of the rate at which natural resources are being used. For example, high levels of water use results in considerable wastewater pollution, that results in degraded water quality, as well as increased demand for energy to pump and treat water. The indicator is a gross measure of water supplied through water supply facilities in a jurisdiction divided by the total number of people in the jurisdiction.

Illustration
The indicator will be displayed as the water use per capita in litres/capita within jurisdictions in the basin and the basin as a whole. The indicator is a measure of both residential and industrial/commercial water use.

Limitations
Data are readily abundant although it needs to be gathered in a consistent format. Ground water sources from private wells are excluded.

Interpretation
Water use symbolizes societal regard to resource use. North Americans, including those in the Great Lakes region, have very high rates of per capita water use compared with other developed nations, and reductions would result in reduced stress on the ecosystem. Water use is high and growing in places such as Toronto, in spite of efforts over the years to encourage water efficiency and conservation.

Comments
Canada and the United States are among the highest water using nations, per capita on the Earth.

Unfinished Business
- Need to add a discussion related to understanding the trends presented by the indicator. For example, will a baseline of "ideal" or "sustainable" water consumption rates need to be developed to determine if data collected on an annual basis (or another regular interval) reveals positive or negative trends in the amount of water consumed.

Relevancies
Indicator Type: pressure
Environmental Compartment(s): water, humans
Related Issue(s): stewardship
SOLEC Grouping(s): land use, **societal**
GLWQA Annex(es):
IJC Desired Outcome(s):
GLFC Objective(s):
Beneficial Use Impairment(s):

Last Revised
Feb. 16, 2000

Energy Consumption (Indicator ID: 7057)

Measure
Energy use in kilowatt hours per capita.

Purpose
To assess the amount of energy consumed in the Great Lakes basin per capita, and to infer the demand for resource use, the creation of waste and pollution, and stress on the ecosystem.

Ecosystem Objective
Sustainable development is a generally accepted goal in the Great Lakes basin. This indicator supports Annex 15 of the GLWQA.

Endpoint
Resource conservation minimizing the unnecessary use of resources is an endpoint for ecosystem integrity and sustainable development.

Features
The indicator is useful on a state/province/country basin basis. The trend for energy use has been increasing over time, which this indicator will depict as it tracks annual energy use.

Illustration
The indicator will be shown as a measure of kilowatt hours electrical energy used per capita.

Limitations
While the data are readily abundant for electrical energy, it will be more difficult to assess other energy sources such as hydrocarbon used in transportation, wood burned in fireplaces, natural gas and furnace fuels. This will require considerable effort.

Interpretation
Energy is a key aspect of ecosystem sustainability. The second law of thermodynamics is a starting point to understanding the way in which energy plays a key role in long term sustainability. Reducing the use of energy of all kinds will reduce 'entropy' and ensure a more sustainable future. Although electrical energy is a good proxy for total energy use, a complete accounting of all energy used is desirable. Although all forms of energy should be considered for conservation, electrical energy is used as a proxy.

Comments
Canada and the United States are among the highest energy consuming nations on Earth.

The indicator provides a quantitative measure of the rate at which non-renewable natural resources are being used up and that renewables are being consumed.

Electrical energy generation is among the largest source of smog related pollutants. In addition, it also generates a major share of all greenhouse gases that are responsible for global climate change.

Unfinished Business
- Need to develop a more quantitative endpoint.
- Need to determine how this indicator will be presented - as a graph, on a map, etc?
- Need to develop a baseline or reference value to be used in assessing whether energy use is increasing or decreasing over time.

Relevancies
Indicator Type: pressure
Environmental Compartment(s): air, humans
Related Issue(s): climate change, stewardship
SOLEC Grouping(s): land use, **societal**
GLWQA Annex(es): 15: Airborne toxic substances
IJC Desired Outcome(s):
GLFC Objective(s):
Beneficial Use Impairment(s):

Last Revised
Feb. 16, 2000

Solid Waste Generation (Indicator ID: 7060)

Measure
Amount of solid waste generated per capita (tons and cubic metres).

Purpose
To assess the amount of solid waste generated per capita in the Great Lakes basin, and to infer inefficiencies in human economic activity (i.e., wasted resources) and the potential adverse impacts to human and ecosystem health.

Ecosystem Objective
Sustainable development is a generally accepted goal for Great Lakes basin society. This indicator supports Annex 12 of the GLWQA.

Endpoint
The reduction of waste to levels achieved in some European and Asian nations.

Features
Solid waste is generated and deposited on land or is incinerated and the residue remains on the land while other contaminants are redistributed by air and water sources. Solid waste represents a significant portion of all human land activities that generate waste and pollution and is stressful to the ecosystem. The indicator represents waste that goes to hazardous and non-hazardous landfills, as well as incinerators. Annual rates of waste generation will be presented by this indicator and bi-annual reporting will be useful.

Illustration
The indicator will be displayed as tons (tonnes) and cubic metres per capita in jurisdictions and for the basin over time. The indicator will be for all solid wastes over time.

Limitations
Although data are available for all jurisdictions, this indicator will require data coordination and integration. Variability in waste stream composition will result in the need for different types of measurement, such as weight versus volume, and may produce conflicting indications of progress. Regardless of the manner of disposal, the measure should consider the total volume of disposed solid waste. Therefore, important land contamination issues, such as acres of land fill space, will not be dealt with in this indicator.

Interpretation
Solid waste provides a measure of the inefficiency of human land based activities and the degree to which resources are wasted by the creation of waste. Reducing volumes of solid waste are indicative of a more efficient industrial ecology and a more conserving society. Reduced waste volumes are also indicative of a reduction in contamination of land through landfilling and incineration and thus reduced stress on the ecosystem.

Comments
Canada and the U.S. are among the highest waste producers on Earth. Reuse and recycling are opportunities to reduce solid waste levels.

Solid waste stored in sanitary landfills is a major source of methane, a very important greenhouse gas responsible for global climate change. Incineration of mixed solid waste has been shown to be a significant source of mercury and dioxins.

Unfinished Business
- Need to determine a specific endpoint.
- Need to determine a baseline value to use for assessing positive or negative trends in the amount of solid waste generated.

Relevancies
Indicator Type: pressure
Environmental Compartment(s): air, land, humans
Related Issue(s): contaminants & pathogens, climate change, stewardship
SOLEC Grouping(s): **societal**
GLWQA Annex(es): 12: Persistent toxic substances
IJC Desired Outcome(s): 7: Virtual elimination of inputs of persistent toxic substances
GLFC Objective(s):
Beneficial Use Impairment(s):

Last Revised
Feb. 16, 2000

Vehicle Use (Indicator ID: 7064)

Measure
Amount of vehicle miles traveled. Number of licensed vehicles in the Great Lakes basin. Amount of fuel consumed.

Purpose
To assess the amount and trends in vehicle use in the Great Lakes basin and to infer the societal response to the ecosystem stressed caused by vehicle use.

Ecosystem Objective
This indicator supports Annex 15 of the Great Lakes Water Qualilty Agreement. An alternative objective is to reduce stress on the environmental integrity of the Great Lakes region caused by vehicle use.

Endpoint
Declining trends in automobile dependence and vehicle emissions.

Features
Automobiles are the primary contributor to the level of greenhouse gases in the atmosphere. Emissions from vehicle use also contribute contaminants to air and water systems. Automobile oriented development degrades the liveability of urban environments. This indicator assesses the societal response to the well-known consequences of automobile use by measuring trends in vehicle use. This indicator is reported by measuring vehicle miles travelled, amount of fuel consumed, and car ownership numbers. Vehicle use measures provide data that is not available from modal split measures including possible trends in trip distance (a proxy for sprawl development) and trends in number of trips taken.

Illustration
A chart showing vehicle miles travelled in the basin or amount of fuel consumed over time will best represent this indicator. Graphic representation of this indicator also involves a ratio of vehicle miles travelled to number of licensed vehicles to infer individual automobile use trends.

Limitations
This indicator is limited by details such as different sized cars and trucks will emit different levels of emissions. Daily vehicle miles travelled rates may not take into account a lower number of weekend trips. This measure does not separate miles travelled by trip type, such as commercial goods movement, travel to work and home based trips.

Interpretation
This indicator can be used as a reference, indicating an improvement in the state of the ecosystem, as well as a community's commitment towards ecosystem health. Results for this indicator should be interpreted in conjunction with urban development patterns in the basin and indicators in the Urban Issues suite of indicators. Those collected can also be used to compare areas within the Great Lakes region.

Comments
This indicator should be measured in conjunction with trends in mass transportation (#7012), which is an alternative to vehicle use. Focusing on automobile use and the current transportation trends will lead to the establishment of higher levels of air quality and in turn improved human health. Data for this indicator is produced by census agencies and local transportation planning departments.

Relevancies
Indicator type: response
Environmental Compartment: crosscutting – air, land, and water
Related issues: mass transit, air quality, urban sprawl, smog
SOLEC Groupings: societal responsibility – household/community
GLWQA Annex(es): 10: Hazardous Pollutants, 13: Non-point sources, 15: Airborne Toxic Substances, 17: Research & Development
IJC Desired Outcome(s): 4: Healthy humans, 5: Economic Viability, 6: Biological Integrity and Diversity, 9: Physical Environmental Integrity
GLFC Objectives:
Beneficial Use Impairment(s): 3: F & W Populations, 9: Drinking water, 14: F&W Habitat

Nearshore Land Use (Indicator ID: 8132)

This indicator needs to be linked to #7002 Land Conversion – but we still need to be able to pull out data for 1 km along shore.

Measure
Land use types, and associated area, throughout the Basin. Land use types could include urban residential, commercial, and industrial, non-urban residential, intensive agriculture, extensive agricultural, abandoned agricultural, closed canopy forest, harvested forest, wetland and other natural area.

Purpose
To assess the types and extent of major land uses throughout the Basin, and to identify real or potential impacts of land use on significant natural features or processes, including the twelve special lakeshore communities identified in the Biodiversity Investment Area work in SOLEC 1998-2000.

Ecosystem Objective
Maintain diverse, self-sustaining terrestrial and aquatic communities. This indicator supports Annex 2 of the GLWQA.

Endpoint
No net loss or alteration of significant natural features or processes from current conditions.

Features
This indicator will track trends in land uses over time (ideally 5 to 10 year periods) and focus on identifying areas experiencing the greatest changes in land use intensity over time. To identify and map land uses, this indicator will rely on a variety of methods, including remote sensing; aerial photography; available land use planning data for areas identified as already experiencing rapid land use changes (e.g., urban areas and cottage development); municipal data on building permits; and official plan/zoning bylaw amendments. Subsequent yearly monitoring will establish an increase or decrease in the extent of major land use types. This indicator is related to indicator #8136, Nearshore Natural Land Cover and to #7002, Land Conversion.

Illustration
For each lake basin, lake, jurisdiction, and ecoregion, a table or graph will display annual changes in the area and degree of interspersion of each land use (same as Land Conversion indicator).

Limitations
Data collection may be difficult for many reasons. Collection of detailed data on a regular basis may be difficult due to the large area and the number of different jurisdictions to be examined. Differences in types of land use planning data collected by jurisdictions may also hamper the collection of consistent data to support this indicator. Some limited historical data are available on land use types, but these data are focused on specific areas. A few basin-wide studies have been conducted that would provide a basic description of land use trends (e.g., U.S. National Shoreline Inventory from the early 1970s and a recent IJC water levels reference study) but it may be difficult to compare these data due to differences in methodology and generalizations that may have been used.

Interpretation
Developing a baseline for this indicator will require both a review of existing data sources to determine their usability, and a discussion among agencies to establish a common list of land use types and parameters. Computerized analysis of satellite imagery may provide a cost-effective means of data collection. A more detailed study and groundtruthing of selected areas, however, will be needed to assess the relationship of land use changes to the loss or alteration of significant natural features and processes. In particular, results from this indicator should be compared to results from indicator 8129, Area, Quality, and Protection of Special Lakeshore Communities, to assist in identifying land use change patterns that threaten natural habitats.

Comments
The twelve special lakeshore communities are sand beaches, sand dunes, bedrock and cobble beaches, unconsolidated shore bluffs, coastal gneissic rocklands, limestone cliffs and talus slopes, lakeplain prairies, sand barrens, arctic-alpine disjunct communities, Atlantic coastal plain disjunct communities, shoreline alvars, and islands. _ Nearshore communities.

Unfinished Business

Relevancies
Indicator Type: state
Environmental Compartment(s): land
Related Issue(s): habitat
SOLEC Grouping(s): **nearshore terrestrial**, land use

GLWQA Annex(es): 2: Remedial Action Plans and Lakewide Management Plans, 11: Surveillance and monitoring
IJC Desired Outcome(s): 6: Biological community integrity and diversity, 9: Physical environmental integrity
GLFC Objective(s):
Beneficial Use Impairment(s): 14: Loss of fish and wildlife habitat

Last Revised
July 2, 2002

Wastewater Treatment and Pollution

New Indicator; (Proposed sample report available)

Measure:

Proportion of the population served by municipal sewage treatment facilities, percent of collected wastewater that is treated, level of municipal treatment provided (primary, secondary, tertiary, and/or advanced treatment technologies), and the loadings of metals, phosphorous, BOD, and organic chemicals that are released by sewage treatment plants and industrial discharges into water courses of the Great Lakes basin.

Purpose:

This indicator will assess the scope of municipal sewage treatment and the commitment to protecting freshwater quality in the Great Lakes basin. The quality of wastewater treatment in terms of the loadings of pollutants discharged into the Great Lakes basin will be used to infer the potential adverse impacts to human and ecosystem health.

Ecosystem Objective:

To reduce the pressures induced on the ecosystem by insufficient wastewater treatment networks and procedures and further progression towards sustainable development.

Endpoint:

To provide municipal sewage treatment facilities to the greatest portion of the population and to treat all wastewater to a quality that ensures waters released back into the ecosystem approach the ambient quality of the area they are being discharged to.

Features:

This indicator measures progress toward safe and innocuous wastewater releases to the environment. In particular, this indicator provides information on how well local governments are managing wastewater generated in their communities. Measuring the level and type of treatment used provides additional information on the quality of the water returned to the environment. Measures of the percent of population connected to the municipal treatment facilities (over a select time period) can be used as an indicator of sprawl, since greenfield development may not supported by municipal infrastructure services.

Illustrations:

- Percent of population connected to sewage treatment systems over specific time period (by basin?) - bar
- Percent of wastewater treated vs. percent of wastewater collected - line
- Level of treatment based on type of treatment - pie
- Loadings over time (by jurisdiction / by basin / overall?) – multi bar

Limitations:

Though most municipalities produce wastewater treatment data, it may require considerable effort to collect all the information, particularly in smaller or more rural communities. Wastewater treatment technologies vary by municipality and, in some cases, may be difficult to classify. Although data are largely available, they are not collected on a necessarily comparable fashion for both the U.S. and Canada. Some work is required to ensure that Ontario data is consistent with the U.S. Since much industrial wastewater flows to municipal sewage treatment facilities the efficiency of these in reducing waste can be hidden.

Interpretation:

Wastewater treatment is dependent on the quality of the incoming wastewater, the state of the technology used to process the wastewater, and other factors such as fugitive leaks that can increase volumes dramatically at certain times resulting in a deterioration of the quality of wastewater. This indicator can also be used to monitor progress toward more comprehensive wastewater treatment in terms of quality and scale of the treatment system.